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(56) Documents Cited
GB 1545389 A WO 98/32815 A2 WO 94/21512 A1
US 4548629 A US 4445916 A US 3874184 A

(58) Field of Search
UK CL (Edition R) F4P PCA PFF
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EPODOC, PAJ, WPI.

(54) Abstract Title
Purification and liquefaction of natural gas.

(57) A process for purifying and liquefying natural gas comprises a plurality of heat exchangers, a refrigeration system, at least one compressor, two turbine expanders, a purification column 130 and a LNG flash vessel 124. The vapour 26 from the LNG flash vessel is diverted to be used in an alternative application to the LNG 24. Preferably the vapour 26 is diverted to a methanol plant integrated with this plant or to an electricity generation plant. The refrigeration is preferably provided by a propane/ethylene cascade unit.

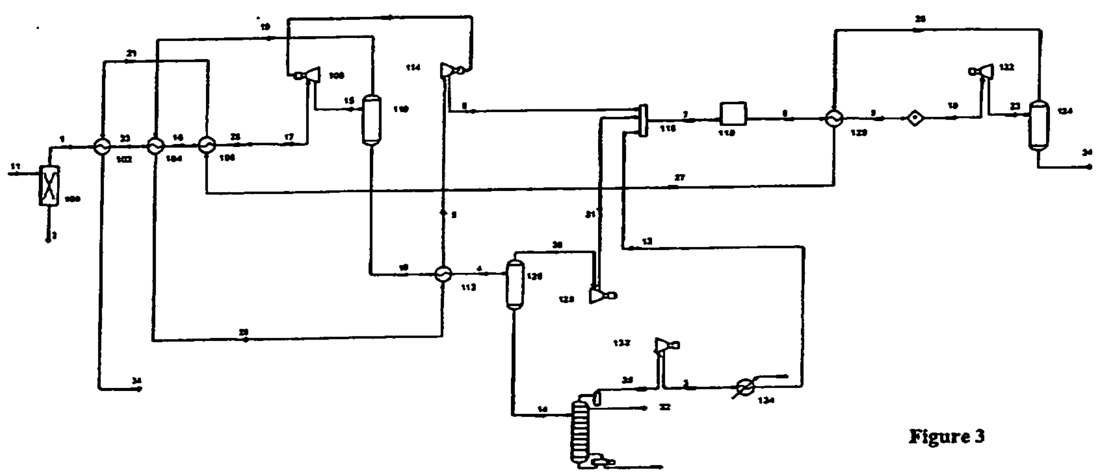

Figure 3

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

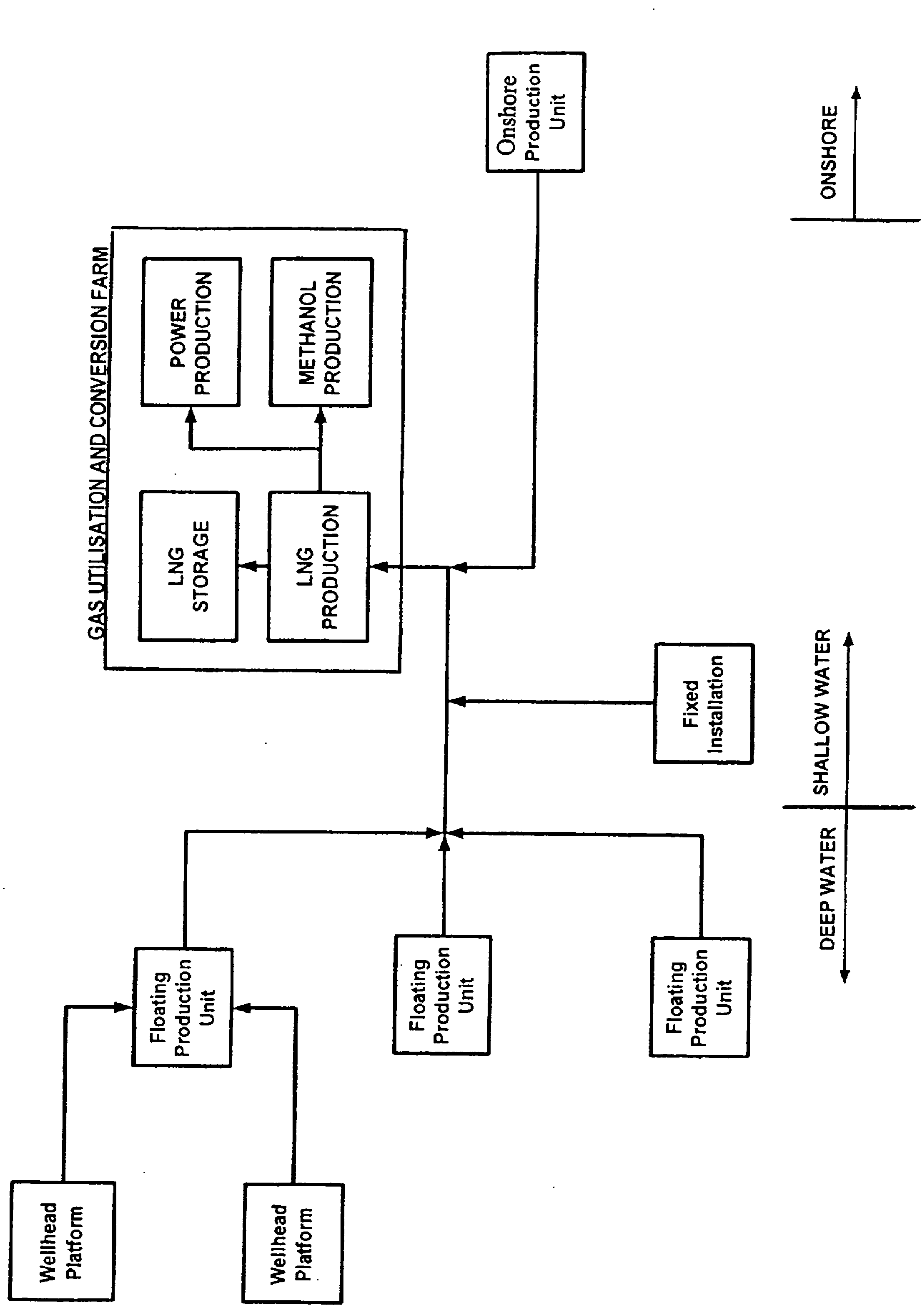
Onshore Production Unit
ONSHORE
GAS UTILISATION AND CONVERSION FARM
POWER PRODUCTION
METHANOL PRODUCTION
LNG STORAGE
LNG PRODUCTION
Fixed Installation
SHALLOW WATER
DEEP WATER
Floating Production Unit
Floating Production Unit
Floating Production Unit
Wellhead Platform
Wellhead Platform

Figure 1

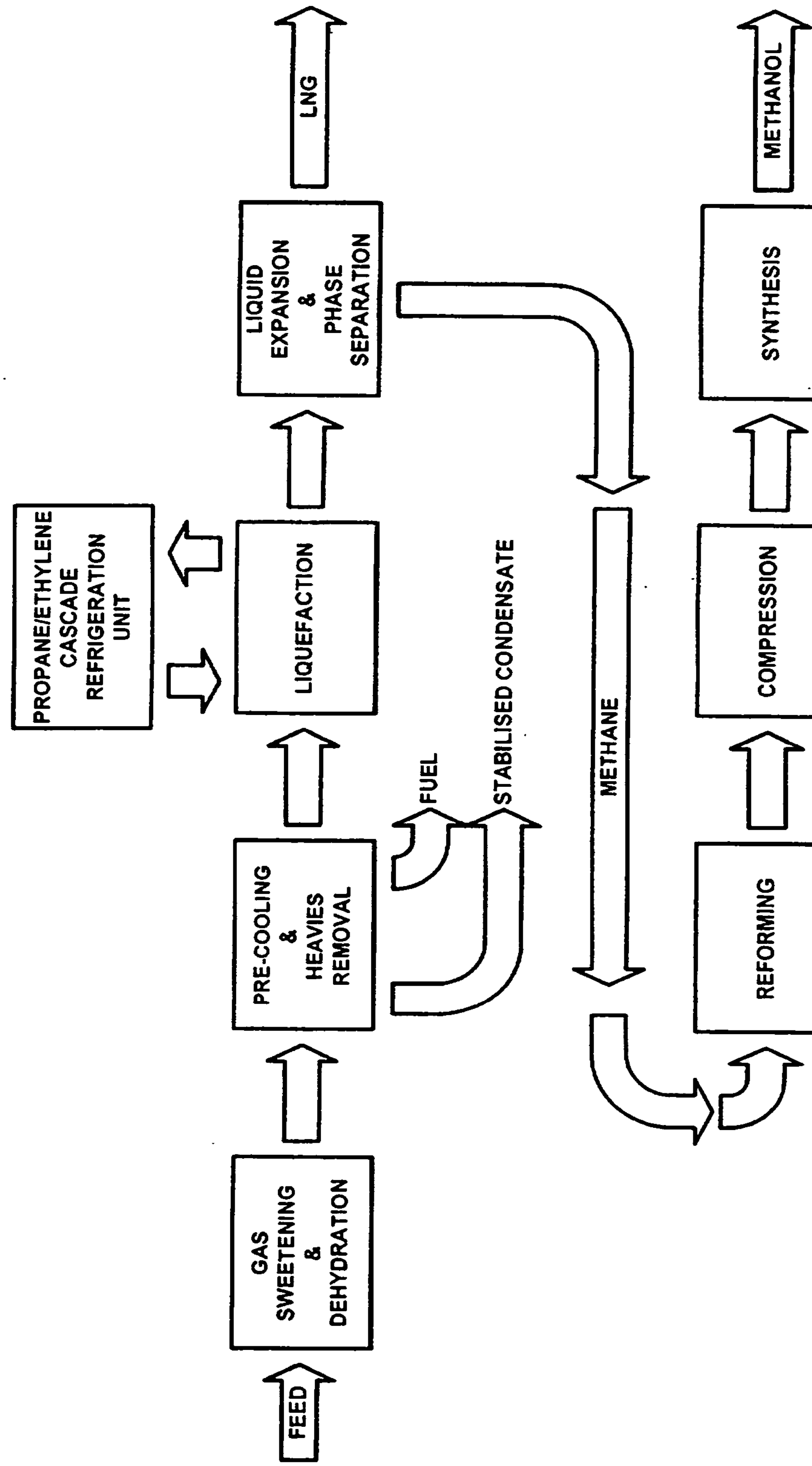
FEED
GAS SWEETENING & DEHYDRATION
PRE-COOLING & HEAVIES REMOVAL
FUEL
STABILISED CONDENSATE
LIQUEFACTION
PROPANE/ETHYLENE CASCADE REFRIGERATION UNIT
LIQUID EXPANSION & PHASE SEPARATION
LNG
METHANE
REFORMING
COMPRESSION
SYNTHESIS
METHANOL

Figure 2

3 / 4

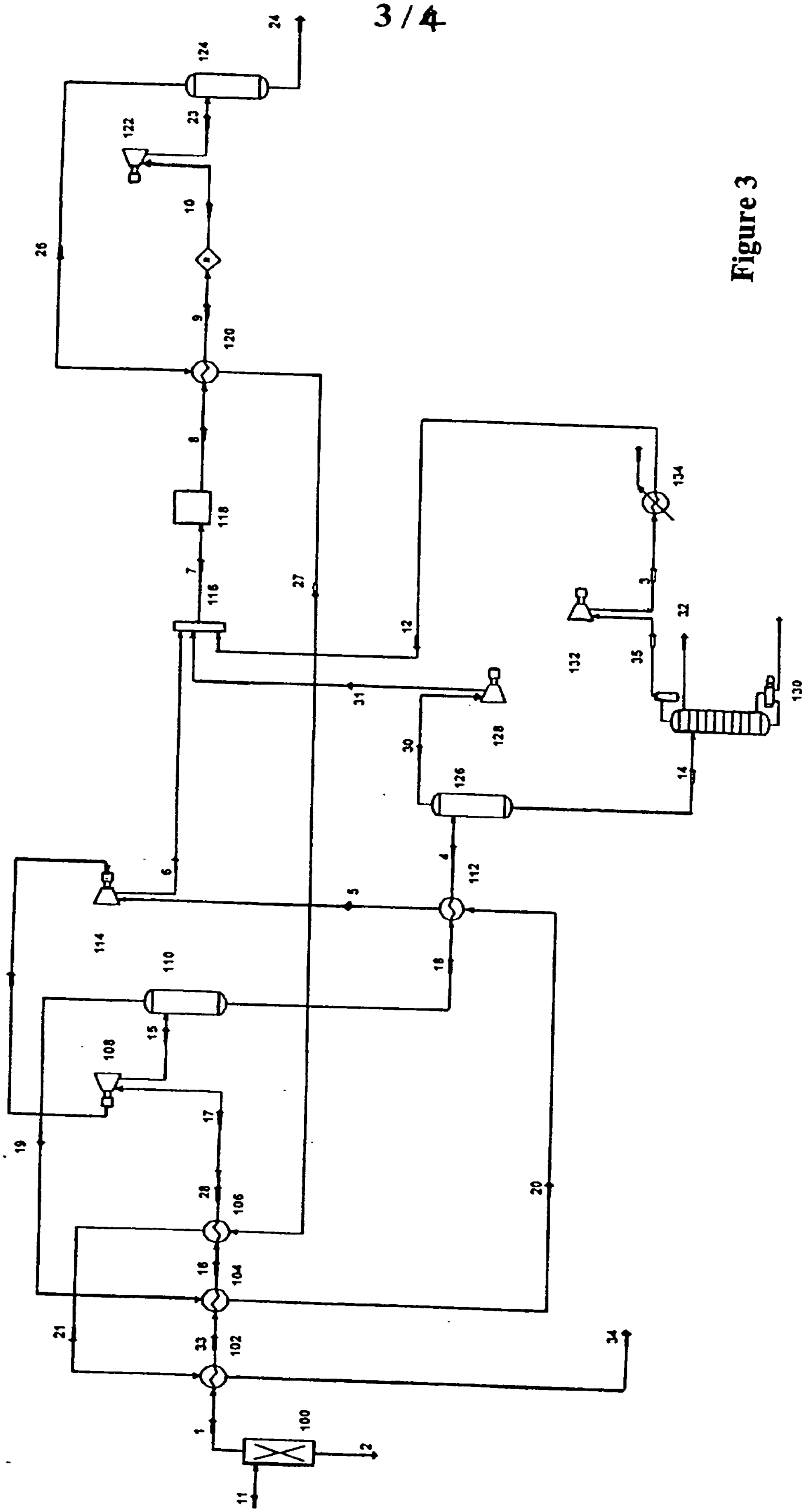

Figure 3

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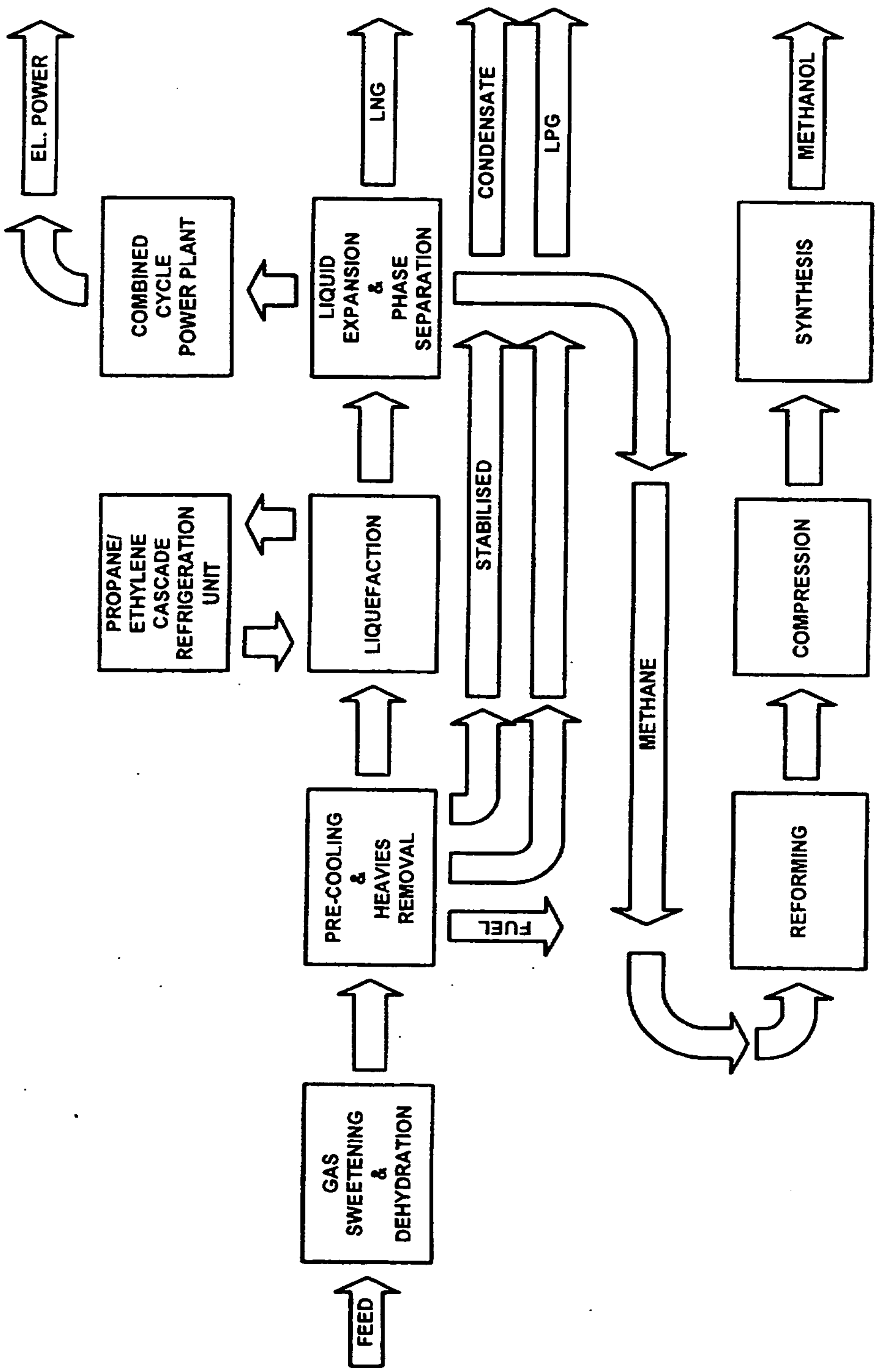
FEED
GAS SWEETENING & DEHYDRATION
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LIQUID EXPANSION & PHASE SEPARATION
COMBINED CYCLE POWER PLANT
EL. POWER
LNG
CONDENSATE
LPG
STABILISED
METHANE
REFORMING
COMPRESSION
SYNTHESIS
METHANOL

Figure 4

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Process for Treating and Liquefying Gaseous Mixtures Such as Natural Gas

This invention relates to the treatment of natural gas including its conversion to useful products.

In particular the invention relates to a process for combining processes with the liquefying of natural gas to Liquefied Natural gas (LNG) in a more cost efficient way.

Natural gas has been discovered and is available in parts of the world where there the local demand is far lower than the normal economic rate of production. It is therefore advantageous to liquefy the natural gas to form LNG which can then be transported usually by sea going vessels specifically designed for the purpose to regions of the world where demand for natural gas is greater. Frequently the sources of natural gas are off-shore resulting in the advantageous location of the natural gas liquefaction facility off-shore close to the location of gas production. Typically a liquefaction facility involves a scheme where gas is drawn from a number of installations, both deepwater and shallow water.

Before and during the liquefaction process it is necessary to remove various compounds normally found in natural gas to prevent them solidifying after liquefaction and clogging up the distribution and control systems. Typically water and carbon dioxide have to be removed as well as higher fraction hydrocarbons. A typical feed gas could have the following composition 80-85

mole % C1; 5-10 mole % C2; 2- 8 mole % C3 and 1-5 mole % C4+ (sour gases, water, and other constituents are excluded for convenience), but the invention could also be applicable to compositions outside these ranges.

The liquefaction process typically requires the feedstock to be cooled to about minus 160 degrees C which requires significant amounts of energy and investment in capital equipment.

It is an objective of the present invention to provide a liquefaction and treatment process which is more energy efficient. It is also an objective of the present invention to provide a liquefaction and treatment process which may produce a range of alternative by-products.

According to the invention there is provided a process for the treatment and liquefaction of natural gas at elevated pressure including a first heat exchange means, first expansion means, gas liquid separation means, compression means, refrigeration means, a second heat exchange means, a second expansion means and an LNG flash unit, characterised in that the flash gases exiting the LNG flash unit pass through either the first or second heat exchangers and are diverted to an alternative external use for the flash gases in combination with the LNG production.

Preferably the refrigeration means is provided by a propane/ethylene cascade unit. Preferably the flash gases are diverted to a methanol plant, which preferably includes additional olefin processes. The flash gases may also or instead be diverted to an electricity generation plant.

Various embodiments of the invention will now be described in more detail with reference to the following figures in which:

Fig. 1 is a block flow diagram showing the feeding of a liquefaction and treatment process of a first embodiment of the invention from a number of sources,

Fig. 2 is a block flow diagram showing a second embodiment of the invention,

Fig. 3 is a pipe flow diagram showing the layout of the process of a further embodiment of the invention,

Fig. 4 is a block flow diagram showing a further embodiment of the invention, and

Fig. 5 is a schematic diagram of an alternative heat exchange arrangement.

Referring to fig. 1 natural gas is provided from one or a number of production facilities including sub-sea well head feeding floating production platforms as well as shallow water production platform and even land based sources. The natural gas is fed into the process plant or farm according to this first embodiment which comprises LNG production and storage combined with methanol production and the production of electric power. The methane could also be used for other processes such as a Fischer Tropsch process, or the production of bio-proteins.

By a combined development of independent process plants normally required to produce LNG, methanol and electric power separately, into one gas utilisation and conversion farm provides a significant overall cost reduction. The separate processes of LNG liquefaction plants, methanol plants and power plants utilising natural gas and are designed, and required, to operate continuously under very carefully designed and controlled conditions. The combined systems of the present invention also require careful design to provide sufficient tolerances to account for variability caused for example by changes in the feedstock composition and to carefully control the cross boundary dependencies between the LNG and other process(es).

Fig. 2 shows a block flow diagram for a combined LNG and methanol plant according to a second embodiment of the invention.

Fig. 3 shows a more detailed flow diagram of a third embodiment showing a plant that treats feed gas for 'sour' gases such as CO_2, and H_2S, H_2O and heavy hydrocarbons, stabilises the condensate, liquefies the feed gas and delivers pure methane to consumers. The feedstock gas enters the plant at 100 which are Gas Sweetening and Dehydration Units. These may be an Amine process for removal of CO_2 and H_2S following a system of Molecular Sieves for dehydration.

The feedstock gas then passes through a series of three feed gas pre-coolers; a First Feed Gas Pre Cooler 102, a Second Feed Gas Pre Cooler 104 and a Third Feed Gas Pre Cooler 106.

The gas then passes to a Gas Expander 108. The gas expander directly drives the compressor 114 in a subsequent stage. The gas feedstock then passes to a gas liquid separator 110. The separated gas from separator 110 passes back through the second pre-cooler 104 and is passed through a gas/liquid heat exchanger 112. And then passes to the Gas Compressor 114 and subsequently to a Tee connection at 116.

The separated liquid from the separator 110 passes directly to the same gas liquid heat exchanger 112 followed by a further liquid separator 126. The gas separate from this passes to a compressor 128. And then to the Tee connection 116. The liquid separate from the separator 126 passes to the condensate stabiliser 130 and the top fractions are compressed by an overhead vapour return compressor 132 and pass through an overhead gas cooler 134 before joint the rest of the flow at the Tee connection 116. The lower fractions pass through the condensate stabiliser and leaves at the bottom as stabilised condensate.

The main feed gas continues from the Tee connection 116 to a refrigeration unit 118. This may comprise a propane / ethylene cascade unit, a multi component single cycle refrigeration unit, or other similar device. The feed gas enters the refrigerant evaporator and is cooled down to approximately –104 °C. This temperature is sufficient to liquefy more than 70 vol% of dry treated feed gas at elevated pressures. The feed continues to a liquid expander 122 and then enters an LNG flash drum 124. An overhead gas stream 26 is produced by the flash vessel 124 and is passed though the liquid sub cooler 120 into feed line 27

to the third pre-cooler 106 and via feed line 29 to the first pre-cooler 102. This final product of the flash gases from the LNG plant then exits via the pipeline 34. The flash gas is predominantly a methane rich gas with nitrogen and has the required quality as feed gas for methanol and power plants.

A typical world scale methanol plant requires a feed stock of 30 to 45 million standard cubic metres of natural gas. Gas purification involving the removal of heavies and solids are required. By combining an LNG plant with a Methanol plant in this way there is a huge potential in savings on liquid sub cooling in the LNG plant and gas purification in the Methanol plant.

Industrial power turbines as used in combined cycle power plants requires fuel gas of stable calorific value for optimum efficiency. The flash gas has high purity and stable composition and thus is highly suitable as fuel gas for the industrial turbines.

The associated gas volumes offshore Angola, for example, are of such an order of magnitude that by converting it all to Methanol the world total Methanol supply will be significantly larger than its demand. However, a world scale Methanol plant could supply raw methanol as feedstock to e.g. a UOP/Hydro Methanol to Olefin process yielding higher commercial value products as Ethylene and Propylene.

For larger feed rates additional installations is required. This could be powerplants, carbon black, bio-proteins etc.

A near to shore power station connected to an offshore power cable to a land based Power Grid could utilise large volumes of natural gas. The demand for electricity is increasing in many parts of the world.

Fig. 4 is a block flow diagram which shows a proposed flow scheme for a large gas utilisation and conversion farm with LNG, methanol and power production. Side products are stabilised condensate and commercial grade LPG. The proportions of methanol and power produced may be varied and optimised, for example, to as their relative prices change.

Fig. 5 and 5a respectively show arrangements to utilise the relatively low temperature of the flash gases, in fig. 5 by a number of heat exchanges in series (as shown in fig. 3), and in fig. 5a by using a multi-stream heat exchanger such as plate fin or spiral wound heat exchangers. In both figures a first line 27, 29, 34, and second line 19, 20 run from the flash vessel and flow through heat exchange means so as to absorb energy from feed line 1, 17. The two arrangements are identical in function.

For a typical feed of 25 to 30 million standard cubic metres a day of natural gas this plant would produce:

LNG: 5.4 MTPA

Methanol: 900 000 TPA

El Power: 780 MW

Propane: 1 500 m^3/day

Butane: 1 600 m^3/day

Condensate: 2 650 m^3/day

Claims

1. A process for the treatment and liquefaction of natural gas at elevated pressure including a first heat exchange means, first expansion means, gas liquid separation means, compression means, refrigeration means, a second heat exchange means, a second expansion means and an LNG flash unit, characterised in that the flash gases exiting the LNG flash unit pass through either the first or second heat exchangers and are diverted to an alternative external use for the flash gases in combination with the LNG production.

2. A process for treatment and liquefaction of natural gas according to the previous claim characterised in that the refrigeration means is provided by a propane/ethylene cascade unit.

3. A process for treatment and liquefaction of natural gas according to any previous claim characterised in that the flash gases are diverted to a methanol plant

4. A process for treatment and liquefaction of natural gas according to claim 3 that the methanol plant includes additional olefin processes.

5. A process for treatment and liquefaction of natural gas according to any previous claim characterised in that the flash gases are diverted to an electricity generation plant.

6. A process for treatment and liquefaction of natural gas substantially as herein described and illustrated.

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Application No:	GB 0009313.8	**Examiner:**	Matthew Jefferson
Claims searched:	1 to 6	**Date of search:**	8 August 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): F4P (PCA, PFF)

Int Cl (Ed.7): F25J 1/02, 3/00, 3/08.

Other: Online: EPODOC, PAJ, WPI.

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X Y	GB 1545389	(AIR PRODUCTS) See page 2, line 65 to page 4, line 19 and figure.	X: 1 & 2. Y: 3 & 4.
X Y	WO 98/32815	(ABB RANDALL CORP) See page 4, line 20 to page 6, line 29 and figure 1.	X: 1, 2 & 5. Y:3 & 4.
Y	WO 94/21512	(OFFSHORE PRODUCTION SYSTEMS) See page 5.	3 & 4.
X Y	US 4548629	(CHIU) See column 3, line 1 to column 5, line 33 and figures.	X: 1, 2 & 5. Y: 3 & 4.
X Y	US 4445916	(NEWTON) See column 4, line 47 to column 6, line 5 and figures.	X: 1, 2 & 5. Y: 3 & 4.
X Y	US 3874184	(HARPER ET AL) See column 2, line 15 to column 5, line 2 and figure 1.	X: 1, 2 & 5. Y: 3 & 4.

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
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